Does reducing take of winter run sized juvenile salmon increase survival through the Delta.

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Introduction:

Over the past four years, EWA assets for salmon have been primarily used to reduce take, for the implementation of VAMP and for a few modest actions upstream (mostly incidental to the movement of water from upstream sources to the Delta). To determine if EWA assets have been used in the most effective manner, the relative benefit of the present uses of EWA need to be compared to others. As a first step however, it is important to estimate how the present uses benefit the salmon populations – more specifically does minimizing take increase their survival through the Delta.

Conceptual Model

Reducing exports to reduce direct losses of winter run increases the survival of juvenile salmon through the Delta. Direct losses are only a part of the total loss (direct and indirect) associated with project pumping.

Evidence of links between exports, loss and survival

This analyses attempts to quantify the links between exports, winter run loss at the CVP/SWP Facilities (as determined using Delta size criteria curves) and winter run survival through the Delta (an index of obtained using differential catch of winter run sized fish (using the Frank Fisher curves) at Sacramento and Chipps Island (entry and exit to the Delta respectively)). Seasonal/annual estimates of the various parameters are used. This analysis is shown as an example of how we are trying to quantify and verify our conceptual models. We are limited by few data points, noise and accuracy in the parameters measured and by estimates of winter run loss and survival that are calculated using two different size criteria that may not truly index winter run abundance at / or between locations.

A Direct loss versus exports: To determine if reducing exports reduces take on an annual time scale, the direct loss of winter run sized salmon at the facilities (using Delta length-at-date curves to distinguish race) for each year was regressed to combined average exports between December 1 and April 15. Direct loss of winter run and exports regression is not statistically significant when all of the data is used (Figure 1). The relationship is significant ($p<0.01$) when the 2000-2001 data is removed (Figure 2).

> **1. Why would the 2000-2001 data be an outlier?** It is unclear why loss in 2000-2001 was so much higher relative to the average export rate in comparison to the other years. Based on the monitoring most of the fish entered the Delta later that year (Feb and March) than in most of the other years (Dec). White et al, (2001) suggested high mortality during rearing and downstream migration would be consistent with poor river habitat conditions in a dry year. Furthermore our estimate of survival through the Delta (as shown later) was the lowest estimated which would be consistent with and in part due to the high take at the CVP/SWP.

B. Direct loss/Chipps Island abundance versus exports: Direct loss is a measure of the winter run sized fish lost at the two facilities. It does not take into consideration the number of winter run sized fish available in the Delta each year that would be exposed to direct projects impacts. A better indicator of the direct impact of the projects would be the direct loss expressed as a fraction of the number of winter run in the Delta. We have used an estimate of abundance of winter run at Chipps Island as an index of abundance of winter run in the Delta (also calculated using Delta curves). Chipps Island absolute abundance was estimated by expanding the monthly winter run catch by the time and space sampled. The monthly estimates were then summed to get an estimate of abundance for the season. Direct salmon loss ranged up to about 4 percent of the Chipps Island abundance estimate except in 2000-2001 when it was nearly 9 percent.

The relationship between direct loss relative to Chipps Island abundance and exports is not statistically significant when 2000-2001 is included. The relationship without the 2000-2001 data is statistically significant ($p<0.05$). The equations with or without the 2000-2001 data are similar. This may indicate that direct loss is a higher proportion of the surviving population to Chipps Island when mean exports between December 1 and April 15 are high. If the Chipps Island absolute abundance estimates are accurate, then direct loss relative to the Chipps Island abundance may provide a better indication of the relative impact loss has on winter run salmon in the Delta than comparing loss to the winter run JPE.

C. Winter run survival versus direct loss and direct loss/Chipps Island abundance: To determine if losses are affecting survival through the Delta, winter run survival through the Delta was correlated to direct losses (figure 4), and direct loss/Chipps Island abundance (figure 5). Winter run survival through the Delta was estimated using the mean seasonal catch per cubic meter (CPUE) at Chipps Island divided by that at Sacramento. The mean seasonal CPUE at each location was calculated averaging the monthly (December – April) CPUE values. Monthly values were estimated by averaging weekly values obtained from average daily catch per cubic meter values obtained with the trawls within the week (USFWS, Stockton CA Juvenile Salmon Abundance and Survival Annual Report). It is interesting to note that the annual CPUE values for the two locations are correlated (figure 6), indicating that generally more winter run sized salmon (using the Frank Fisher curves) emigrate from the Delta when larger numbers migrate into the Delta. Survival for winter run through the Delta was inversely related to both direct loss and direct loss/Chipps Island abundance. The strongest correlation was between survival and direct loss/Chipps Island abundance indicating that survival for winter run sized fish increases as the proportion of loss relative to the number emigrating past Chipps Island decreases.

Some biologists believe that direct losses are only part of the overall effect of exports on salmon in the Delta. The relationship between exports and winter run survival should explain more of the variability in survival than direct loss alone because it would account for both the direct and indirect losses due to project pumping, but it did not (figure 7). In any event these relationships generally support reducing exports to reduce take and improve the survival of winter run and other juvenile salmon attempting to migrate downstream to Chipps Island.

Our measure of survival through the Delta is gross. Furthermore, exports are described by a mean value over a 4 ½ month period in all years. These measurements may not be precise enough to get strongly statistically significant relationships even if they exist. Estimating loss and Chipps Island absolute abundance using Delta curves to define which fish to count and using the Frank Fisher curves to estimate winter run survival through the Delta adds additional uncertainty to these relationships because there can be large differences between these two models in how many salmon are characterized as winter run (Figure 8). The differences between the number of salmon characterized as winter run using each model is shown for salvaged juvenile salmon in 1996 -1997 in figure 9. Genetics would be a better way to characterize these fish and may help us determine which growth curves are most appropriate to use at the various monitoring locations, however, length-at-date criteria will never be able to fully discriminate among Central Valley salmon runs because of the diverse habitats these fish occupy and the complex life history strategies that have evolved.

D. Are we curtailing exports at the proper times or could we manage curtailments differently to improve survival through the Delta for winter run and spring run juvenile salmon?

Three time periods during the year appear to have peaks of winter run sized fish take at the fish facilities. In some years (2001-2002 and 2002-2003) peak loss at the facilities was between mid-December and January (figures 10, and 11). In other years (1998-1999, 2000-2001 and 2003-2004) peak losses were between February 15 and April 15 (Figures 12, 13 and 14). Lastly there are years when peak losses are between the two other periods, i.e. between January 15 and March 1 (1999-2000) (figure 15). The highest number of genetic winter run is seen at the SWP/CVP between February 15 and April 1, while some are seen as early as September 15 (figure 16). Relatively high numbers are sometimes observed between November 15 and December 15 (figure 16). Based on analysis of samples from the SWP/CVP for one year, some genetic spring run fall in the winter run size range (S. Greene, personal communication). This is consistent with past observations of spring run in the winter run size range leaving Mill and Deer creeks.

Providing protective actions to minimize take (not just preventing reaching the take limit) when peaks are observed or are expected to occur in the Delta would have the greatest benefits. The time period between Feb 15 and April 1 appears to be the most important time period for winter and possibly yearling spring run. The Delta cross channel gates are closed during this period. Reducing exports at the CVP and SWP during this time period when take is high would further protect these races and potentially increase survival through the Delta. Even with the gates closed juvenile salmon migrate into the interior Delta where survival has been shown to be less.

Additional justification for reducing exports to improve survival is based on the relationship between Georgiana Slough late-fall survival relative to that at Ryde versus exports. As exports decrease, Georgiana Slough survival relative to that at Ryde increases. The newest data includes releases made in December of 2003. This data fits close to the regression line, however while marginally significant ($p<0.10$) the relationship has a lot of variability (Figure 17a). The data obtained from the ocean fishery shows the same pattern as that derived from the Chipps Island trawl recovery data (Figure 17b). Ocean recovery information is not available for the last two years of releases (12/02 and 12/03).

Part of the uncertainty with this relationship is knowing what percentage of the population moves into the interior Delta to experience the greater loss as a function of exports. If it is a high percentage a large proportion of the population would benefit from export curtailments. If it is a small percentage the benefits of curtailments would be less. The Delta Cross Channel work team is in the process of writing up the last few years of experiments evaluating the period when juvenile salmon are the most vulnerable to diversion into the Delta Cross Channel and Georgiana Slough. Reducing exports when your populations have the greatest risk (moving from the interior Delta) may provide the greatest benefits.

E. Are there other actions in the Delta that we should consider that may improve the survival of winter run sized salmon through the Delta?

Closing the DCC gates more frequently between November 1 and January 31 may also provide significant population benefits. Closing the gates in this earlier period may reduce the number of winter run that enter the interior Delta. Direct loss of winter run sized fish appears to be less when the DCC gates are closed and a lower percentage of the water is diverted into the interior Delta, both when loss is a function of the JPI (Alice Low, personal communication) as well as a function of Chipps Island absolute abundance (Figure 18). For fall run it has been concluded based on modeling of coded wire tag recoveries that closing the Delta cross Channel gates and reducing exports will increase the survival of juvenile salmon smolts migrating through the Delta (figure 19) (Newman, 2003). How much improvement can be made optimizing EWA assets is uncertain but should be further assessed.

Literature Cited:

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